Palabras clave
tukapu código Inka
Key words
tukapu *code* *Inka*

Resumen
En este estudio se ofrece una nueva aproximación al código gráfico de los diseños incaicos llamados *tukapu*. Propongo que los *tukapu* son marcos esquemáticos que encarnan relaciones por medio de las configuraciones de sus propiedades gráficas. Usando una análisis formal, describo las características mayores del código (las propiedades, los formatos y las entidades) e ilustro las operaciones sistemáticas que parecieran ser usadas para generar variantes en el código y navegar entre las variantes. Después, aplico el método derivado del análisis del código a algunos ejemplos de *tukapu*, e ilustro la congruencia entre las relaciones encarnadas en los gráficos y las relaciones que se encuentran en la organización social de los Inkas. Datos sugeridos de otros campos (arqueología, etnografía y etnohistoria) son citados para apoyar el análisis y la aproximación que se desarrolla aquí.

Abstract
This paper outlines a new approach to the graphic code of Inka designs called tukapu. I propose that tukapu are diagrammatic frameworks that embed relationships in the configuration of their graphic properties. Using formal analysis, I describe the major characteristics of the code (the properties, formats, and entities) and illustrate systematic operations that appear to generate variants in the code and navigate between them. I apply the method arising from the formal analysis of the code to several examples of Inka tukapu, and illustrate the congruence between the graphic relationships in the tukapu and the relationships that underpin several spheres of Inka socio political organization. Suggestive data from other fields (archaeology, ethnography and ethnohistory) are cited to support the analysis and approach to tukapu developed here.

Tukapu, a graphic code of the Inkas

Mary Frame[1]

Introduction

Tukapu (*tocapo*) are the geometric designs on Inka tapestry garments, according to Guaman Poma de Ayala, a native chronicler writing shortly after the conquest of Peru. In *Nueva Corónica y Buen Gobierno* (1993 [1615]), which takes the form of a lengthy and copiously illustrated letter to King Philip III of Spain, Guaman Poma provides a fund of visual information on *tukapu*. Different people in varied contexts are shown wearing garments with *tukapu* during the course of the chronicle, which contrasts the orderliness of life under the Inkas with the abuses they suffered under the colonial regime. The framed designs appear on tapestry tunics, in bands at the waist or covering the entire garment, on belts, and in the broad borders of dresses and shawls. In the illustrations of Inka life before the conquest, the garments with *tukapu* often are worn by named people of royal or noble status, while illustrations of the colonial period show people of varied rank wearing garments with *tukapu*. Guaman Poma draws a similar range of *tukapu* on garments of the Inka and colonial periods, but reflects a change in who was wearing *tukapu*. His perspicacity in observing the latter point may indicate that we can accept his graphic implication that the code of *tukapu* survived the upheaval of the

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conquest, while the display of *tukapu* came to serve different ends within a transformed colonial society.

Similar designs encased in square or rectangular frames appear on Inka and colonial drinking cups made of wood or metal or on pottery or other objects. Most *tukapu* on extant objects are geometric designs, although a small number are identifiable figures.[2] The more numerous geometric designs encompass a range of symmetrical and asymmetrical shapes: diamonds, squares, triangles of several types, lozenges, zigzags, figure-eights, Z-and S-shapes, crosses and X-shapes, T-shapes, H-shapes, and a variety of others. The ample variety of shapes and the range of colors have the potential to encode meaning systematically, a point that has not gone unobserved by others.

Tukapu is also the name used here for the system or code comprised of individual designs, also called *tukapu*. As I will illustrate, *tukapu* is an indigenous sign system, one of the «alternate literacies» of the Inkas (Boone and Mignolo 1994), because it is systematic and has coherency. Like the better known Andean literacy of the *khipu*, which is a recording device consisting of colored and knotted cords, *tukapu* relies heavily on spatial configuration for conveying meaning. Although *khipu* and *tukapu* are different from each other in medium and perhaps in message, they are even more different from sign systems that reproduce speech. Like the *khipu*, *tukapu* appears to be a semasiographic or non-glottolized system (Sampson 1985), that is, a system of signs that is not closely linked to speech.

Restrictive linguistic definitions as to what constitutes writing do not adequately encompass the different material ways of encoding and transmitting knowledge in native American literacies (Mignolo 1994:253). At a minimum, there is a need to redefine «writing» to fully include the semasiographic systems of the Andes (Boone 1994:13-17), or to reposition alphabetic writing and alternate literacies in a more comprehensive scheme of inscriptions that encompasses notations (Salomon 2001; Goodman 1981). Notations typically include musical and dance scores, knitting instructions, and mathematical symbols. A second pressing need is to identify what Boone has called «the logical system (a system comparable to a grammar) that drives and orders» the Andean literacies (1994:16).

A broader approach to discourse than is traditionally offered by linguistics is useful in approaching the alternate literacies of the Andes. Inkan modes of discourse include not only the graphic textual mode of *tukapu* and the visual-tactile mode of the *khipu*, but also the processual modes of material practices (textile making or agriculture, for example) and even, I would suggest, the structuring modes of organization (socio-political or cosmological, for example). The latter modes, while rarely mentioned in discussions of writing [3], are also signifying practices of culture, and signifying practices can illuminate the complex dynamics of intertextuality (Brokaw 1999:57). The different modes of discourse can be described in terms of property configuration, similar to the terms that will be used here to describe *tukapu*. Recognizing that common properties and formats configure a range of signifying practices in Inka culture suggests how the textual code of *tukapu* articulated with repetitive practices and durable institutions of the empire. *Tukapu* appear to have been a codified means to make visible and permanent the configuration of relationships, the essential ordering, of a range of signifying practices.

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2 Examples include birds, fish, snakes, insects, feathers, tunics, headdresses, and shields.

3 Mignolo (Boone and Mignolo 1994:297), who is explicit in his recognition of «the links between weaving, agriculture, and writing», draws primarily on a Chinchero ethnography (C. and E. Franquemont 1987).

Various hypotheses about *tukapu* have been advanced during the past fifty years. Some have attempted to treat *tukapu* as signs within systematic codes (phonetic/syllabic or numeric have been experimented with) [4], while others have posited that *tukapu* are a standardized iconography or a collection of heraldic symbols (Rowe 1979; Rojas y Silva 1981; A. Rowe and J. Rowe 1996). Still others have argued that *tukapu* make distinctions of rank and political organization (Zuidema 1991: 165), or suggested that they demarcate ethnic, political, and religious status (Cummins 1994: 199), but without elucidating a logic by which *tukapu* convey distinctions.

The approach outlined here investigates the structuring of the *tukapu* code and the way in which meaning might be expressed, that is, the logic that drives and orders the code. I propose that *tukapu* are diagrammatic frameworks of relationships and that relationships are embedded in properties such as symmetry, direction, number, concentricity, color, and value. The properties, and the formats by which they are organized, are semi-mathematical in character, and the combination of properties in *tukapu* has a potential to express relational ideas graphically. The approach is applied to several examples to illustrate the types of relationships that can be conveyed in graphics. The insistent relationships expressed by the formal properties of *tukapu* have parallels in the relationships that underpin domains of Inka culture. Certain *tukapu* that will be discussed exhibit a strong isomorphism with socio-political domains. Suggestive data from archaeology, ethnohistory, and ethnography will be offered, which reinforce the parallels between some *tukapu* and specific domains of reference.

Overview of a Graphic System

My research to this point suggests that four main areas could be described as material characteristics of the *tukapu* code. They are the entities that comprise the code; the formal properties of the entities; the formats by which the properties are organized; and the operations by which variants are generated. These four areas appear to have interconnected roles in the production of expressions in *tukapu*. Although this discussion largely refers to the framed *tukapu* on Inka and Colonial artifacts, related designs that are not framed are considered to be extensions of the same graphic code.

***Material characteristics of* tukapu**

Entities: The code has different types of graphic entities that can be broadly grouped on the bases of symmetry or scale. I make distinctions between four types of entities: graphs, graphemes, compounds, and elements. I use the word graph for the finite symmetry designs[5] enclosed in frames. Finite symmetry designs include figures that have reflection and/or rotation symmetry, or figures that are asymmetric (figure 1, top row). Examples include diamonds, paired triangles, lozenges, and many more geometric and figurative designs. The word grapheme is used for *tukapu* that are infinite symmetry patterns [6], that is, miniature patterns that repeat a single graph within a frame (figure 1, second row). The repetition in a grapheme can be organized in bands or in grids or lattices. Compounds are those *tukapu* that include two or more different entities within the frame (figure 1, third row). As illustrated here, both graphs and graphemes can be compounded or combined in the same frame. The final term, element, is applied to the simplest particles, or roots, from which graphs or

4 Arellano (1999: 258-266) provides a useful summary of the majority of such studies.

5 The symmetry analysis used here follows Washburn and Crowe (1988). For finite designs, see p. 57.

6 For infinite symmetry patterns in bands and planes, see one dimensional and two dimensional patterns in Washburn and Crowe (1988: 58-61).

graphemes are constructed. Different elements of the same size can be blended in a *tukapu* graph, or small-scale elements can be infixed in the corners or centers of framed *tukapu* (figure 1, bottom row: infixed small-scale elements are shown with darker outlines). Infixing small elements, blending equal-sized elements in a graph, and compounding graphs and graphemes are different ways of constructing graphic conflations in *tukapu*. Presumably, graphic conflation corresponds with building in more complex relations, and relations between relations, in *tukapu*. The operative difference between infixing, blending, and compounding entities may be one of emphasis or weight given to the elements by their relative size in a particular *tukapu*.

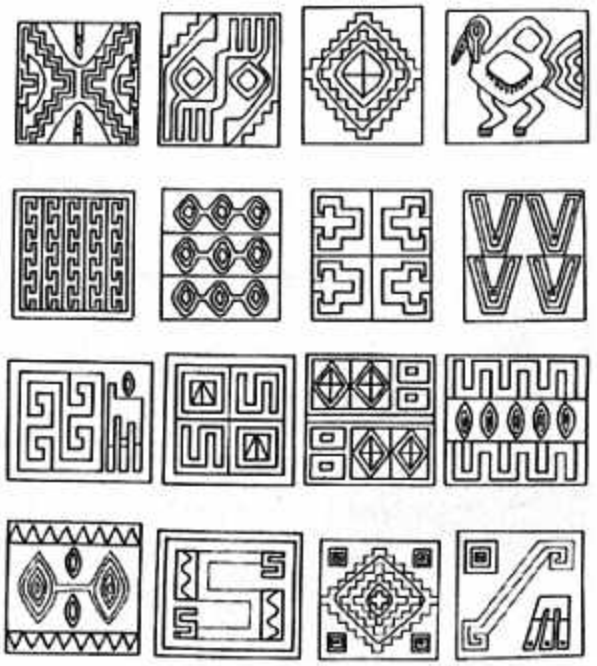

Fig. 1: The graphic entities in the tukapu code can be broadly grouped as graphs (top row), graphemes (second row), compound graphs and graphemes (third row), and elements (bottom row, added elements shown with darker outlines).

Properties: The formal properties that have a potential to embody relationships include symmetry, direction/orientation, number, concentricity, color/value, and possibly others. Each of the properties has expressive potential, and the combination of properties has the potential for other levels of relational expression. Shape, or the outline that delineates a shape, also has communicative potential, but it could be referential to some degree, rather than relational.

Formats: The formats that conceptually organize a property appear to take the form of categories, pairs, series, sets, sequences, or spatial arrays. The formats seem to contextualize specific properties by the implicit relationships they set up between variants. The simplest relationship in a format is to one other variant as part of a ranked pair; more elaborate relationships can be embedded in categories or spatial arrays. There does not appear to be a one-to-one relationship between properties and formats. The same format can organize different properties, and by the same token, properties can have more than one format. Number expressions, for instance, appear to be formatted in pairs, series, sets, sequences, or spatial arrays in different *tukapu*.

Operations: Close variants among *tukapu* suggest that standard operations generate related *tukapu*. Operations, isolated during the study of various groups of related graphs, include combination, repetition, addition/omission of elements, substitution, reversal/inversion, change of scale, re-centering, and abbreviation. Operations are applied to individual properties, elements or, at times, to the complete graph. When a property such as direction or orientation is reversed, or when the colors of figure and ground are inverted, there is a pointed indication that the modified property signifies. Operations not only generate variants systematically, they also highlight what *is* a signifying property. Recurrent graphs that have many variants arising from standard operations can usefully be approached as «families». Graphs that blend several elements exhibit connections to more than one family of graphs.

In my conceptualization of the code, the entities, properties, formats, and operations are not exclusive – they overlap and interconnect in the production of expressions. A major

overlap occurs between properties and formats. The potential for expression in the properties of *tukapu* appears to be intimately associated with the way in which the properties are formatted. The following discussion deals with the formatting of properties.

Organizational Formats of the Properties

Categories of Symmetry. Symmetry may well be the dominant property in the *tukapu* code, a primacy it appears to have had in many pre-Inka graphic codes (Frame 1986; 2001; n.d.). Symmetry is an effective categorizing tool[7] because the categories are inclusive (every graph can be classified) and because symmetry is an invariant, or unchanging, property. The symmetry of a graph can be registered at a glance by those who are practiced in discerning differences in symmetry: asymmetry (figure 2, top row), reflection symmetry (figure 2, second row), rotation symmetry (figure 2, third row), and combined reflection/rotation symmetry (figure 2, bottom row). Reflection symmetry is mirroring across one or more axes, while rotation symmetry is a spinning motion around a center point. Asymmetric graphs have neither reflection nor rotation symmetry.

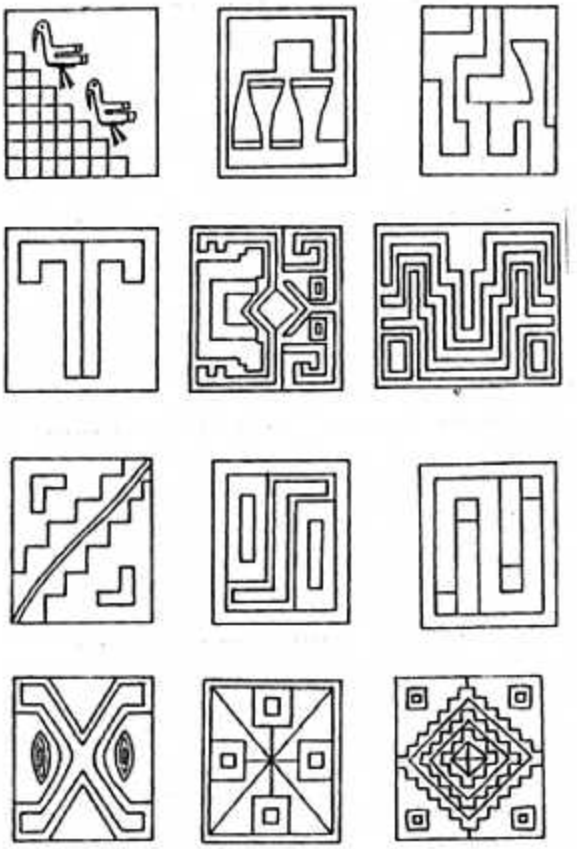

Fig. 2: Categorizing graphs by symmetry distinguishes between tukapu that are asymmetric (top row) and ones that are symmetrical by reflection (second row), by rotation (third row), and by both reflection and rotation (bottom row).

Graphs have the potential to express ideas of space or time through symmetry and number, or the relationship between space and time in certain cases, as I will illustrate with an ethnographic example from Taquile, Peru. Reflection axes produce spatial partitions into a given number of sectors. Rotation symmetry is marked by a given number of intervals, corresponding to the number of times a graph becomes congruent with itself in a full-circle rotation around a point. Rotation intervals are like calibrated marks on dials, and dials can express temporal ideas of duration, interval, or sequence. Asymmetric graphs that have neither reflection nor rotation symmetry still embed a number value (one) in the non-partitioned space and the single point of congruency in a complete rotation.

Graphemes can be classified by the symmetrical motion that generates the repeated pattern, as well as by the symmetry of the entity that is repeated. Mathematicians accept seven classes of symmetry patterns in bands (Washburn and Crowe 1988: 58-59) and seventeen in planes (1988: 59-60). Each class is generated by one of four rigid motions in the plane, or combinations of them (1988: 44-51): translation (exact repetition), reflection (mirroring across an axis), glide

7 Washburn (1999) discusses the cultural salience of symmetry and suggests that the rotational motifs in Puebloan pottery can be understood through their connection with Hopi practices and beliefs.

reflection (mirroring across an axis and «gliding» forward), and rotation (spinning around a point).

Symmetry is useful for taxonomic classifications because the categories are inclusive, discrete, and unranked, a point that could have been appreciated by people such as the Inka who did not have an alphabetic script. Structures, processes and motions, as well as three-dimensional objects and two-dimensional images, can be described in symmetrical terms. The importance of symmetry in Andean modes of discourse, I believe, can hardly be overestimated. Classification by symmetry is strategy that reduces the tremendous variety in the world to a manageable group of equivalent, but discrete, categories. With graphic imagery such as *tukapu*, a symmetry classification can include both geometric and figurative graphs.

Pairs, and pairs of pairs: Organization in pairs is perhaps the most primal formatting strategy in Andean modes of discourse, including the textual mode of *tukapu*. Pairs are united by the relationship of complementary opposition, a pervasive patterning in Andean cultures that has been termed dualism [8]. Pairs are also ranked internally, so that one half of the pair is the dominant one. This durable habit of mind ranks people, objects, and phenomena: man over woman; sun over moon; day over night. Organizing in ranked pairs reduces memory load and enhances memorability through relationships of complementarity and hierarchy. Ranked pairs can be extended into pairs of pairs and beyond, producing a subset of numbers generated by successive doubling. Pairs of pairs may relate in a nested relationship to the higher order pair. A prime example of this is the socio-political divisions of the Inka empire. The first-level pairing is the ranked moiety division of *hanan* over *hurin*. Nested within the moieties is a second-level pairing of the *suyus* or sectors: *Chinchaysuyu* before *Andesuyu* in *hanan* and *Collasuyu* before *Condesuyu* in *hurin* [9].

In the graphic code of *tukapu*, various properties appear to be formatted in ranked pairs. The property of direction/orientation, for example, has possibilities of up/down, right/left, vertical/horizontal, clockwise/counter-clockwise, and Z/S pairings. In each directional pair, there is a culturally preferred direction that ranks above the other. Color and value also might be organized in ranked pairs in *tukapu*. Color pairs (yellow and red, for instance) and value oppositions (white and black) are recurrent unions in *tukapu*. We might reasonably expect that white, the color of light, ranked over black, paralleling the ranking of day over night. By the same logic, it could be suggested that yellow, the color of venerated objects such as the sun, maize, and gold, ranked above red in the Inka empire. While some aspects of color and value in the *tukapu* code may be formatted in ranked pairs, other aspects may be formatted in sequences.

Series and Sets: In particular, the property of number is formatted serially, that is, in the series of natural numbers. The series of natural numbers is commensurate with counting by ones, but subsets of numbers are also important in Andean modes of discourse. Weavers use the subset of even numbers almost exclusively when they calculate their warp threads and weaving patterns in pairs, both during warping and on the loom. The subset of numbers derived through successive doubling has already been mentioned. Folding a textile, for instance, produces a successive doubling of creased modules and successive halving of the area in each module. Archaeological textiles such as Inka tunics were apparently folded in standardized ways for burial (A. Rowe 1978).

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8 A large body of literature on Andean dualism exists, but it is beyond the scope of this paper to review it.

9 Zuidema (1964) has written a pioneering study on the social organization of the Inka empire that has influenced many subsequent studies.

In graphemes, that is, *tukapu* that are composed of repeating elements organized in bands or grids, there are indications that the composition of numbers, and not just the quantity or count of iterations, was reckoned. The arrays of graphemes suggest that knowledge of numbers included arithmetic ideas such as component factors. Doubling, tripling, or quadrupling numbers in bands or grids graphically portrays the factors and product of an operation akin to multiplication.

Color might be organized in sets, with the major subsets distinguishing the light/bright colors from the dark/dull colors, an alternation that is striking in some patterns of repetition on Inka tunics that will be discussed later.

Sequences: Both cyclic and linear sequencing appears to be used in *tukapu*. A cyclic sequencing is visible in the gridded areas of *tukapu* on garments and some *keros* or drinking cups. Typically, the same graph repeats along one diagonal within a grid. Between two and nine different *tukapu*, each *tukapu* confined to its own diagonal, repeat in cyclic alternation on garments in the current sample. A few examples repeat *tukapu* on zigzags, that is, diagonals that reverse direction periodically. A less common type of sequencing occurs in the vertical columns of *tukapu* grids. While some garments exhibit sequenced repetitions of *tukapu* on diagonals or verticals, others exhibit only partial sequencing (with interruptions) or no regular sequencing at all.

Concentric graphs are spatially organized in a way that suggests centrifugal or centripetal sequences. Sequence may also format the property of value in *tukapu*. Gradation scales (light to dark or dark to light) are visual orders that are readily perceived. As sequence establishes before/after relationships, the formatted properties have the potential to express relationships of ordinal concepts such as rank or time.

Spatial Arrays: Tukapu are spatially formatted, sometimes by interior divisions into bands or grids and sometimes by invisible axes of reflection or points of rotation. Quadripartition is the most recurrent arrayed format, both in graphs and in graphemes. As the name of the Inka empire was *Tawantinsuyu*, glossed as land of the four quarters or four sectors bound together, the emphasis on four-part spatial division in *tukapu* is, perhaps, predictable. Graphs that are partitioned into four by axes of symmetry are equally as common as graphemes consisting of four elements united within one frame. Quadripartite arrays are particularly replete with spatial relationships: above/below; right/left; vertical, horizontal, or diagonal pairs; sequences on circular or figure-eight pathways. Although quadripartition strongly implies a spatial division, it should be noted that expressions of time and hierarchy could be embedded in quadripartite *tukapu* through the intervals and direction in rotation symmetry or through value sequences, for example. Quadripartite graphemes sometimes exhibit internal paired relationships through the arrangement of pairs of elements in diagonally opposite quadrants.

Spatial arrays appear to express number composition in several ways in *tukapu*. When the same element is arranged in rows and columns within a framed *tukapu*, factors may be visually expressed (figure 3, left). When two or more different elements are alternated in a grid, the unequal constituent numbers appear to correspond more closely with summation. In a three-by-three grid, nine appears to be expressed as four plus five (figure 3, center) or as two plus two plus two plus two plus one (figure 3, right), as well as three threes (figure 3, left). The expanse on a garment or cup that is covered with *tukapu* also arrays a product (or sum) and its component factors (or addends) in rows and columns. Unlike the knots in the Inka *khipu*, *tukapu* do not appear to emphasize expressions of quantity in base 10. Rather, the composition of numbers, or

perhaps operations, appear to be accentuated through the formatting in pairs, multiples, and spatial arrays.

Fig. 3: Expressions of number in tukapu may include products and factors in graphemes (left) and sums of unequal numbers in compound graphemes (center and right).

Spatial arrays of properties may also be conceptually operative, while not discernible in a specific *tukapu* today. Color, for example, could have been conceptually formatted in a spatial array that established relationships that would have been readily apparent to people who participated in the graphic code of *tukapu*. Colors could have had correlates in directions or rank or locale, for instance, that contributed to their expressive value in specific *tukapu*.

The full range of relationships embedded in the formatted properties of *tukapu* is difficult to estimate, and perhaps it will only be possible to recognize a portion of them. Some relationships, color for instance, may have conventional associations within a complex system of relationships that is beyond our means to reconstruct at present. I suspect that there may be an inverse relationship between the simplicity of shape in *tukapu* and the potential to embed relationships. Figures such as quadrangles (diamonds, squares, or rectangles) are particularly replete in symmetry and pairing attributes. The diamond, which is deceptively simple in appearance, is the first *tukapu* that I will use to illustrate how the analysis of the properties and formats outlined here can be used to approach the relationships embedded in *tukapu*.

The Diamond *Tukapu*

The diamond *tukapu* occurs in a range of variants as both a framed and unframed graph on tunics and other artifacts. The diamond is a recurrent graph on Inka tunic fragments found in coastal sites, far from the center of the Inka empire. It is also larger in size and more repetitive than most *tukapu*. The majority of tunics with diamond waistbands (figure 4) repeat the graph sixteen times, eight times on the front and eight on the back. Both the wide distribution and the size and repetitiveness suggest the diamond *tukapu* was deeply entwined with Inka identity. The relationships embedded in the properties of the concentric diamond graph are, as I will illustrate, congruent with fundamental relationships of imperial Inka organization. If the domain of reference of the diamond *tukapu* was the imperial relationships, then there is reason to suggest that self-interest, even "propaganda", was a part of the motivation behind the distribution of tunics to provincial leaders. The institutionalized largesse of the Inka ruler, who alone gave gifts of fine cloth such as diamond waistband tunics, would be an effective means of disseminating the graphic configuration of imperial organization to the provinces where different languages were spoken.

Fig. 4: The concentric diamond is the largest and most repetitive tukapu on Inka tunics. The diamond embeds relationships in its graphic properties that correspond with relationships that undergird imperial organization. Textile Museum 1964.12.2.

The diamond *tukapu* has the same configuration as a schematized or idealized diagram of the empire. The diamond, which in this case is a square turned on its corner, is a finite design. Finite designs, in technical symmetry studies, can be asymmetrical or can have reflection or rotation symmetry (figure 1, top row). The diamond has both reflection and rotation symmetry, and this is a key to its potential to embed multiple relationships. The axes of reflection divide the diamond into two and four sectors, exhibiting an isomorphism that is apparent in the Inka empire (figure 5). As the name says, there were *tawa* (four) *suyus* (sectors) in *Tawantinsuyu*: *Chinchaysuyu*, *Andesuyu*, *Collasuyu*, and *Condesuyu*. Furthermore, there is a two-part division into upper and lower moieties that coincides with the division made by the horizontal axis.

As well, the diamond has rotation symmetry. After every turn of ninety degrees, the diamond (square) becomes congruent with itself, giving four intervals. Like a watch dial, the intervals of rotation have the potential to mark divisions of cyclical time. It could be a cycle of four years, or another period divided into four equal intervals. The Inka year, for instance, may have been divided into four intervals for some purposes[10]. The rotation intervals in the diamond, when combined with the property of direction (clockwise or counter-clockwise), produce sequential order. Sequences, which have before/after relations, can encompass ordinal concepts that include time, hierarchy, or descent, to mention a few. The combination of reflection and rotation symmetry in the diamond has the potential to embed another level of relationship: the conjunction of space and time. The conjunction of space and time is a topic of perennial interest in the Andes, and one to which I will return.

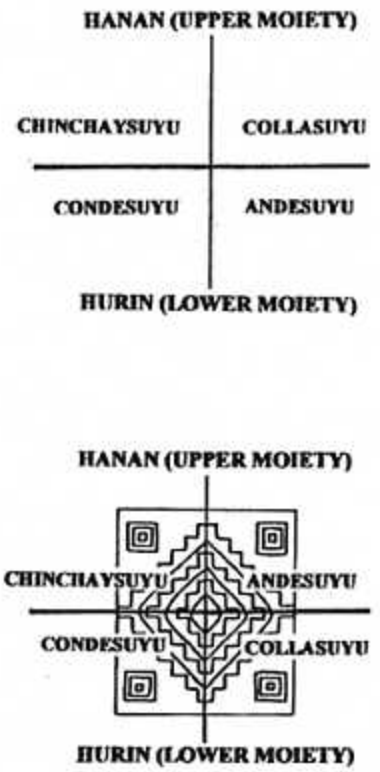

Fig. 5: The diamond tukapu exhibits strong isomorphisms with the socio political configuration of the Inka empire.

Other attributes of the diamond graph also correspond with imperial relationships. The relationship of «the center over the periphery» may be expressed in the sharply contrasting center of the diamond (generally black and white) and the concentric colored outlines (figure 4). Like a pebble tossed into a pond, the energy is concentrated at the center of the graph and lessens as the concentric outlines become larger. This attribute has a parallel in the royal city of Cuzco, the center of the empire and the navel of the universe, which was ringed by lands occupied by people of diminishing prestige. The rank order of Inkas, Inkas-by-privilege, and provincials has a parallel in the centrifugal sequencing of the concentric outlines in the diamond *tukapu*.

The concentric outlines of the diamond graph, generally an alternation of straight and stepped lines, contribute to an optical illusion of a terraced mountain that rises to a pinnacle at the charged center of the diamond. The relationship of «the high over the low» in the optical illusion corresponds with the altitude and the prestige of Cuzco in the highland center of the empire, in opposition to the provincial lands of coast and jungle that slope away

10 The chronicler Betanzos mentions the interval of three months on a number of occasions (1996 [1557]:78, 83, 93, 113). As three months is one half of the interval between soltices, which were marked by the Inkas, it is reasonable to expect that quarterly divisions of the annual cycle were also marked.

to lands of lower altitude and lesser prestige. Geography and topography are spatial metaphors tilted at in the diamond graph that embody relationships of rank –the center over the periphery and the high over the low.

The human body is another metaphor or trope that appears to be at play in the diamond graph, and it also embodies a ranked relationship organized as a pair. The relationship of «the head over the body», whether it be the physical body or the body politic, has a correlate in the stepped yokes of tunics. The triangular yokes on the front and back of some Inka and colonial tunics compose a diamond shape that has the neck aperture in the center. The privileged head of the wearer emerges in the center of the diamond and the top of the tunic. The multiple metaphors of anatomy, geography, and topography that appear to be at play in the diamond graph are concrete embodiments of spatial relationships. The three metaphors have spatial relationships that are coherent with each other and with paired relationships of rank in the Inka empire. The mixing of coherent metaphors might be seen to insist on, and to clarify through redundancy, the relationships of rank embedded in the diamond.

Playful Tropes and Conceptual Metaphors

Work by anthropologists and linguists on «the play of tropes» (Fernández 1991) in spoken language is now well established. It should be no surprise to find the play of tropes in graphic expressions as well. While the play of tropes in *tukapu* cannot be charted through the use of telling words, I have pointed out the graphic traces of tropes in the concentricity, the stepped outlines, and the optical oscillation of the diamond, as well as in its positioning in tunics with yokes. The tropes, drawn from the experiential and sensory realm, embody the relationships that are embedded in the configuration of the diamond *tukapu*.

Recent discoveries by cognitive scientists on the nature of the embodied mind are pertinent for approaching the graphic expressions of *tukapu*. They have discovered that «metaphor is not a mere embellishment; it is the basic means by which abstract thought is made possible» (Lakoff and Núñez 2000:39). Cognitive scientists propose that human beings conceptualize abstractions in concrete terms, using a cognitive mechanism called «conceptual metaphor» that is based in the sensory-motor system of the body (2000: 5). Humans think and communicate about abstractions, in language and in graphics, using metaphors based in sensory experiences. In other words, the abstract relationships of rank likely have a concrete basis in conceptual metaphors. This accords with the traces of tropes (anatomy, geography, and topography) that have been discussed in relation to the diamond *tukapu*. Additionally, cognitive linguists have demonstrated that «spatial relations in a given language decompose into conceptual primitives called *image schemas*», which «are the link between language and spatial perception». Image schemas have spatial logics built into their imagistic structure (2000:30-33), just as the graphic tropes of *tukapu* have. The relationships that are embedded in *tukapu* may reflect the spatial logic of image schemas. While it is cognitive linguists who have noted the existence of image schemas in language, there is no reason to presume that language mediates between image schemas and graphic expressions in *tukapu*.

Conceptual metaphor is defined as «grounded, inference-preserving cross-domain mapping» (Lakoff and Núñez 2000: 6). In graphics, cross-domain mapping is neatly accomplished through superimposition, which makes isomorphisms immediately apparent. Superimposing the diamond *tukapu* on a diagram of the socio-political divisions of the Inka empire (figure 5) reveals the many correspondences noted here: primary partition into two (moieties); secondary partition into four (*suyus*); concentric formation (centrifugal ranking); rotational intervals (time); and the paired, ranked relationships that have just been discussed. The framework of

relationships embedded in the graphic properties of the diamond *tukapu* exhibits a high degree of isomorphism with the socio-political organization of the Inka empire. Although the parts of the empire are not labeled in the graphic *tukapu*, the relationships between the parts are coherently configured in the properties.

Symmetry and the Conjunction of Space and Time

The conjunction of space and time, a topic mentioned earlier but not elaborated upon, is challenging to express in words or even in mathematical symbols. However, a concise graphic method is used in Andes today: symmetry. A certain class of finite designs, which includes the concentric diamond graph, has the necessary symmetrical attributes for such an expression. Finite designs that have both reflection axes and rotational intervals have the potential to express the conjunction of space and time.

The ethnographic example that illuminated the potential of symmetry in this respect is the hexagon as it is woven on textiles from the island community of Taquile [11] in southern Peru. The hexagon design is called *seis suyus*, or six sectors, and it embeds a plan for crop rotation, among other things. The six *suyus* are the traditional socio-political divisions of the island community.

The hexagon is a finite design with reflection and rotation symmetry: it is partitioned into six by reflection axes and has six-fold rotation. The hexagon is a rough chart or map of the six sectors of the island, and it is also a rudimentary calendar that marks time in six-year cycles. Although the long, skinny island does not resemble the hexagon in shape, each sector of the island is located precisely in the woven hexagon through contiguity with its neighbors. The island is also divided into two halves, or moieties. The three *suyus* of the upper moiety are located at the higher end of the island, and they correspond to the pie-shaped wedges in the upper half of the hexagon. The «upper over lower» relationship, reflective of both rank and island topography, is preserved in the hexagon, as well as the location of the six *suyus*. The six-fold rotation of the hexagon, as explained to me by many informants, corresponds to the six-year crop cycle. The cycle runs in a fixed order of potatoes, *oca* (a tuber, *Oxalis tuberosa*), beans, and three fallow years in each sector, but each sector is at a point in the cycle that is offset by one from the adjacent sectors. In each succeeding year, the dial of the hexagon moves one position counter-clockwise and all *suyus* advance one stage through the rotation cycle. The six-year cycle rotates endlessly, coordinating crops throughout the island. Using the hexagon schematic, people can project what crops will be grown where in future years, and they can recall the same information for past years.

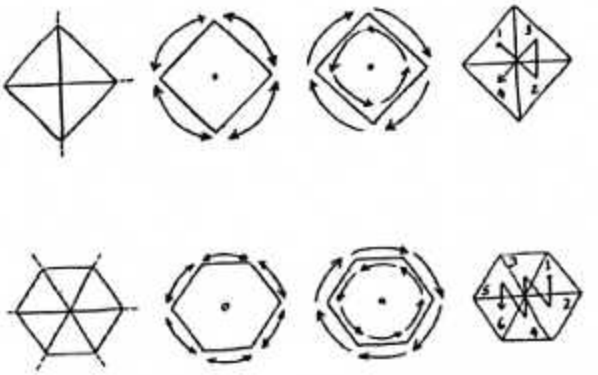

Fig. 6: Comparison of the symmetry, number, and direction properties in the Inka diamond and the Taquile hexagon: partition by reflection (column 1), intervals of rotation (column 2), directions (sequence) of rotation (column 3), and the hierarchy of the suyus (column 4). Pie de figura

[11] I have made extensive collections of clothing and textile tools for the University of British Columbia Museum of Anthropology in Vancouver from one extended family in Taquile. Six collections, including scores of textiles with the hexagon design, were documented over a twenty year period.

Each household on the island is located in time and space in the hexagon. With a small memory load, people know where they fit into a community-wide strategy. The simplicity of conjoining space and time through dual symmetries in finite designs belies the far-reaching impact of the strategy. Agricultural activities of an entire community are coordinated fairly rationally, and on a sustainable basis that protects the soil from depletion [12].

Graphs with reflection and rotation symmetry have the potential to articulate space and time for any activity, not just agriculture. Any rotation of service or access to resources among discrete groups can be coordinated in a graph that has reflection and rotation symmetry. The space and time divisions can be varied numerically, as they are in the diamond *tukapu* and Taquile hexagon, as long as the relationship remains organized by partitions and intervals of reflection and rotation symmetry [13].

Both the Taquile hexagon and the Inka diamond occur with the emphatic frequency that suggests they communicate information of a profound order. The name of the Taquile hexagon, *seis suyus*, has a construction that parallels the name of the Inka empire, *Tawantinsuyu*. Both combine *suyu* with a number affix. Although the hexagon and diamond have different numbers of partitioned sectors and intervals of rotation (six and four respectively), they are graphs that can express a similar range of relationships. In addition to spatial partition, rotation interval, and direction of rotation (compared in figure 6, first three columns), a hierarchical ordering of the *suyus* of both polities can be located within the diagrammatic framework of the graphs. Approached as schematic maps, the hierarchical order of *suyus* in the Inka empire traces a figure-eight pathway through the diamond, and the hierarchical order of the Taquile *suyus* traces a zigzag pathway (right column, figure 6). In both cases, the ranking of the *suyus* intercalates a binary alternation between the upper and lower moieties in the ranking sequence of the *suyus*. The parallels between the diamond and hexagon suggest that the relationships embedded in the Inka diamond might been understood, at least partially, in a manner parallel to the Taquile hexagon.

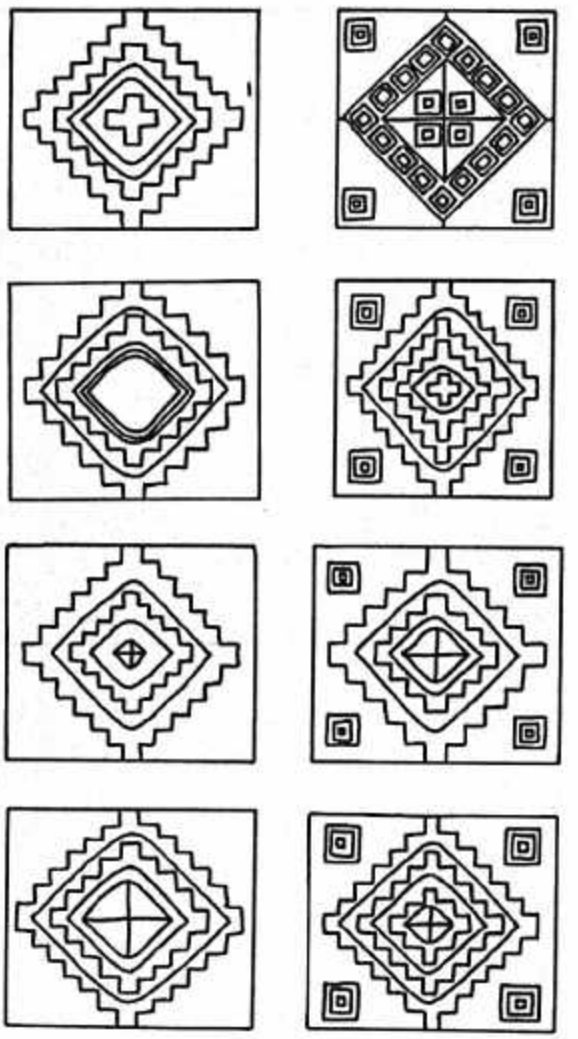

Fig. 7: Variations in the concentric diamond on tunic waistbands.

12 The crop rotation given here reflects practice in Taquile during the 1980's. When I visited Taquile in 2002, the number of fallow years in the six year cycle had been reduced from three to two, and fertilizers were being used more extensively.

13 Three examples that are varied numerically are shown in figure 2, bottom row. The number of partitions and interval in the same *tukapu* can be different.

The range of variants in the diamond *tukapu* is considerable (figure 7). When the property of color is included, every diamond waistband in my sample is different. What is constant is the global configuration of the major properties: symmetry, concentricity, and number of partitions and intervals. Through the formal analysis of properties and formats, I propose that signification in *tukapu* is a domain of reference expressed through relationships. In the case of the concentric diamond, the relationships coincide with what is known about macro relationships of space/time/hierarchy in the imperial Inka realm. It is possible that, if we had more complete information on the relationships that undergird Inka astronomy or cosmology, a similar coincidence between relationships could be illustrated for those domains. «Insistence» is, after all, a hallmark of Inka organization (Ascher and Ascher 1981). If that were the case, the diamond graph would be polysemous in the *tukapu* code, and might reproduce the configurations of domains in addition to the imperial or centralized social organization of the Inka realm.

The Inka Key

The other *tukapu* that I will discuss is dubbed the «Inka key». A well-defined class of tunics (J. Rowe 1979; A. Rowe 1978) alternates two variants of the key *tukapu* in a checkerboard pattern in the upper section (figure 8) [14]. The lower section of the tunics displays six broad bands in two alternating colors. Finely woven Inka key tunics survive on the coast in considerable numbers, indicating that they were also gifts of the Inka ruler to dignitaries in the coastal provinces. I will suggest that the Inka key tunics also may have carried a graphic message of Inka organization (of a different level) to the provincial populace.

The two variants of the key graph differ in the properties of direction and color: a light/bright key with one orientation and a dark/dull key with the opposite orientation. Four colors are invariably used, and two of the four colors are repeated in the bands of the lower half of the tunic. I will discuss relationships embedded in the symmetry and color patterning, in order to illustrate the isomorphisms that exist between the graph and a domain of reference.

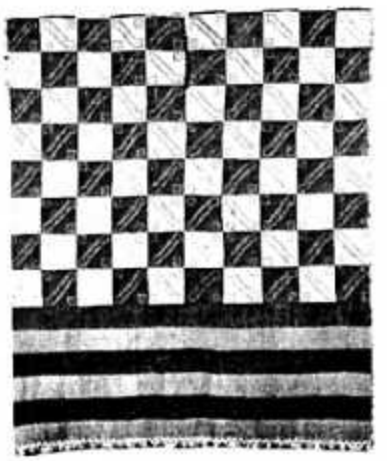

Fig. 8: The two directional variants of the Inka key tukapu and the organization of four colors in the tunic suggests that a double dual relationship is embedded in the graphs and tunic patterning. Textile Museum 91.147.

The Inka key, like the diamond, is a finite symmetry design. However, it has only one symmetry: rotation. The interval of rotation is termed bifold, because the graph becomes congruent with itself at only two points in a complete circular rotation. If registered as a strictly planar design, the two directional variants can be distinguished as clockwise and counter-clockwise, by fixing on the block-like ends of the graph as it spins (see arrows in figure 9, top).

The two directional variants of the Inka key can also be registered as the two halves of a figure-eight cycle. The Inka key belongs to a class of designs referred to as «reverse curves», because the two ends trend in opposite or reversed directions. Reverse curves occur in virtually every Andean art style from the Preceramic Period onward, where they occupy a discrete symmetry category in the graphic codes (Frame n.d.). Many reverse curves are zoomorphized as double-headed serpents.

14 The key *tukapu* also appears in tunics that display many *tukapu*. As many as three color variants of the two directional variants appear in one tunic.

while others are more austerely geometric and look like the letters Z or S. The figure-eight pathway that underlies the class of reverse curves is clearest in those examples where the ends of the graph curl backward on themselves. The Inka key, although angular, has the same formal attributes that suggest a figure-eight pathway: ends that trend in opposite directions and bifold rotation. A figure-eight pathway can be seen to trend through the key graphs and the square elements in the corners of the *tukapu* frame (figure 9, bottom). The two variants, registered as a figure-eight pathway in three-dimensional space, can be distinguished directionally as the «Z» and «S» halves that complete a single cycle.

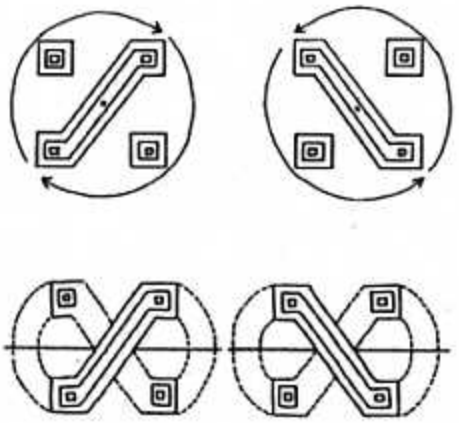

Figure 9. The bifold rotational symmetry of the Inka key tukapu can be registered as circular rotation around a point in the plane (top) or as rotation around an axis in three dimensional space (bottom) that follows a figure eight pathway.

Other Andean modes of discourse, aside from graphic textual codes, emphasize the figure-eight pathway and its alternating cyclicity. Fabric processes, such as looping, lashing, and knotting include figure-eight variants. The *khipu* knot that denotes the integer one is a figure-eight knot. The figure-eight pathway is also used in the orderly winding of the warp, preparatory to weaving. Warpers, positioned at the loom bars, toss the ball of warp yarn over the bar and receive it under the bar, and send it back in the same fashion. This pathway in warping preserves side-by-side order, plus makes an alternating up and down separation of threads. Beyond keeping warps from tangling, the continuous figure-eight pathway is a profound ordering strategy that intercalates binary alternation (up-down) with sequential order (running from left to right). The same alternating cyclicity has been pointed out in Inka socio-political structure (figure 6, top right) where one of the hierarchical sequences of the four *suyus* intercalates a binary alternation between moieties in the sequence of the *suyus*: *Chinchaysuyu* (*hanan*), *Collasuyu* (*hurin*), *Andesuyu* (*hanan*), and *Condesuyu* (*hurin*). In the physical geography of the empire, this ordering follows a figure-eight pathway through space, a pathway that is also traced in the two directional variants of the key graph (figure 9, bottom). The intertextuality between diverse modes of Andean discourse such as textile production, social organization, and *tukapu* appears to be forged on the level of relationships – in this case the alternating cyclicity and directional variants of the figure-eight pathway.

The symmetry of the key graph is two-fold rotation when the pathway is registered as circular (figure 9, top). When registered as a figure-8 pathway (figure 9, bottom), a complete rotation in three-dimensional space produces congruency with the Z and S variants. Both pathways are present and could, potentially, convey different relationships through their separate sequences. Rotation, as I have illustrated for the diamond and hexagon, embeds interval and sequence (figure 6, column 2 and 3), and sequence has the potential to format ordinal concepts such as time or hierarchy. In the case of the Inka key, a sequential temporal expression embedded in the symmetry would amount to a two-part, or alternating, sequence; as a hierarchical sequence, there would be a one-two rank order.

The two-fold rotational symmetry suggests that a domain of reference for the key graph will conform with two-part alternation and a hierarchy of two. These attributes suggest the domain of the *hanan hurin* moieties, which is the highest level of Inka social organization where there is a binary alternation between the halves of a ranked pair. However, the alternating cyclicity

of the figure-eight pathway (figure 9, bottom), as well as the use of four colors organized in two pairs, suggests there is a double dual relationship operating that might include, but go beyond, the expression of dual moiety relationships.

The four colors in Inka key tunics, while not always the same colors, are organized in the same manner. Colors are paired and, almost invariably, one pair is bright red on luminous yellow. The other color pair, sometimes green on purple, is much darker and recedes visually, suggesting a ranked relationship between the two pairs (light/bright over dark). The standard color pairs of the key graphs split and recombine into a new pair, which appears in the broad bands in the lower section of tunics. Invariably, the broad bands alternate red with the darker color of the darker pair, usually purple or dark blue. It is the darker hues from both pairs that are positioned in the lower half of the tunic, perhaps an intimation that darker colors and lower half both correspond with lower rank in the graphic conventions of *tukapu* garments.

The relationships between the colors in the Inka key tunics suggest a domain of reference that will include four entities that exist as standard pairs, but that are also independent to the extent that they can split and recombine into a new pairing. These attributes coincide with the paired and ranked relationships of the four *suyus* that are nested within the two ranked moieties. The four *suyus* existed in a double dual relationship that ranked them within and between moieties. In some situations, they were paired by their rank within separate moieties (*Chinchaysuyu* and *Collasuyu* were first-ranked *suyus* of different moieties); in other situations, they could be paired by their membership in the same moiety (*Chinchaysuyu* and *Andesuyu* belonged to the first-ranked moiety).

The properties of color, value, symmetry and rotational pathways embed relationships that are coherent with each other in the Inka key tunics. In fact, the relationships are so coherent that there is considerable redundancy. The correspondence between the relationships embedded in the properties of the key graph and the relationships that bind together the *suyus* and moieties suggests a socio-political domain of reference, but at the level of moiety/*suyu* administration. The concentric diamond, on the other hand, exhibits a stronger correspondence with the imperial, or centralized, sphere of socio-political organization, as discussed previously.

The archaeological record indicates that diamond waistband tunics and Inka key tunics arrived in the coastal provinces in significant numbers. The gifts of finely woven tunics dispensed to provincial dignitaries conceivably conveyed Inka wisdom, or perhaps imperatives, on several levels of socio-political organization. While fine cloth was apparently a welcome gift, it was also a complex one. By wearing such tunics, one can imagine that leaders of conquered or assimilated provinces asserted their claims to status in the new order and, at the same time, acquiesced to new levels of state authority that overrode their former autonomy.

The foregoing discussions of the Inka key and diamond *tukapu* offer examples of how a formal analysis of properties can be used to probe signification of particular *tukapu*. A complementary approach looks at families of related graphs, and probes how they might interrelate and generate variants in accordance with a logic that drives and orders the code. In the course of my research, I have used both approaches, sometimes simultaneously and sometimes in alternation. Each approach reflects helpfully on the other, as hypotheses generated in one approach can be weighed in the other.

Operations and the Generation of *Tukapu* Variants

Visually related *tukapu* that vary in predictable ways are good indications that rules or conventions operate in the system of *tukapu*. Variables in the diamond *tukapu* (figure 7) include differences in the shape at the center, the presence/absence of concentric squares in the corners of the graph, the number and sequence of outlines, and the color/value disposition. The Inka key *tukapu* is quite standardized in shape and components, but varies in color and direction. It has a diagonal stroke terminating in squared ends that trend in opposite directions, and it has concentric squares in the otherwise empty corners of the frame. In addition to color and directional variants, a number of *tukapu* exist that are related to the Inka key *tukapu* (figure 10). Examining the modifications that give rise to variants in the Inka key provides an outline of the general range of operations that presumably were used to vary or expand expression.

A large class of variants on the Inka key *tukapu* is configured as an X-shape (figure 10). The presence of diagonals with squared ends that toe outward is the visual cue that I have taken to indicate family membership. Superimposing the two directional variants of the key graph generates the X-shape. Some X-shaped variants assemble four key graphs (or four halves of two graphs) in a configuration that is more strongly quartered by axes of reflection symmetry. Repeating key graphs or derived X-shapes is an operation that produces variants in the number of iterations and the spatial array. Small-scale elements can be added to the space surrounding the main figure, adding references that appear subordinate to the main graph. The property of direction is modified in the final examples (bottom row), where the squared ends that are attached to the diagonal are modified into hooks and trend in the same direction rather than in the opposite direction. This change nullifies the two-fold rotation symmetry, while the diagonal suggests that some aspects of the Inka key *tukapu* remain salient in the related graph.

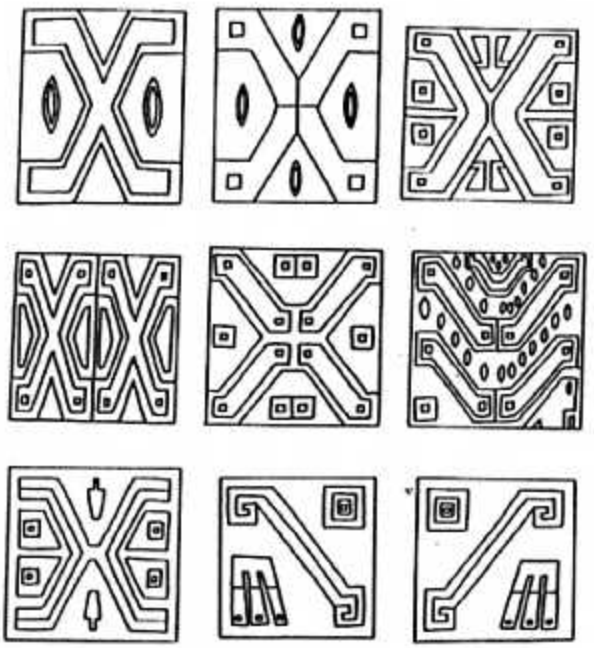

Fig. 10: Variants and hybrids of the Inka key graph are generated by standard operations, which include combination, repetition, reversal, addition/omission of elements, symmetrical reconfiguration, and direction change.

From assembling this family and other families of related graphs, a range of operations that navigates between variants emerges: combination, repetition, abbreviation, addition/omission, expansion/contraction, reconfiguring parts, and reversals/inversions. The operations emphasize the expressive potential attached to what I have identified as the properties, in that the operations pointedly modify the symmetry, number, direction, concentricity or color/value in the graph. The operations themselves are often organized along the lines of the formats of properties. Some operations are organized in pairs as diametric opposites (reversals and inversions), while others are organized in sets or series (repetitions that extend, duplicate or multiply). Other operations employ metonomy (part for the whole), changes in scale, or symmetrical reconfiguration. There is a consistency in the approach to the structuring of

operations, properties, and formats as they are described here that suggests the parts of the overall *tukapu* system are integrated and organized logically.

Roots, Variants, and Hybrids

Using the operations just described, it is possible to hypothesize how hybrid graphs arise from the conflation of two graphs. A visual conflation of the Inka key *tukapu* and the concentric diamond *tukapu* can be illustrated (figure 11) that is consistent with a presumed conflation in expression. The superimposition of the directional variants of the key graph produces an X-shaped graph with squared ends that toe outward. A conceptual layering of the diamond and X-shaped graph and the abbreviation of the squared ends of the key graph to concentric squares produce a common variant of the diamond graph with squares in the corners of the frame (figure 11, bottom). The concentric diamond with squares is a visual and, I would suggest, a semantic conflation. The combination of the diamond graph (the centralized relationships of the empire) with the key graph (relationships between moieties and *suyus*) results in a graph that has the potential of coherently expressing the relationships of both spheres of socio-political organization.

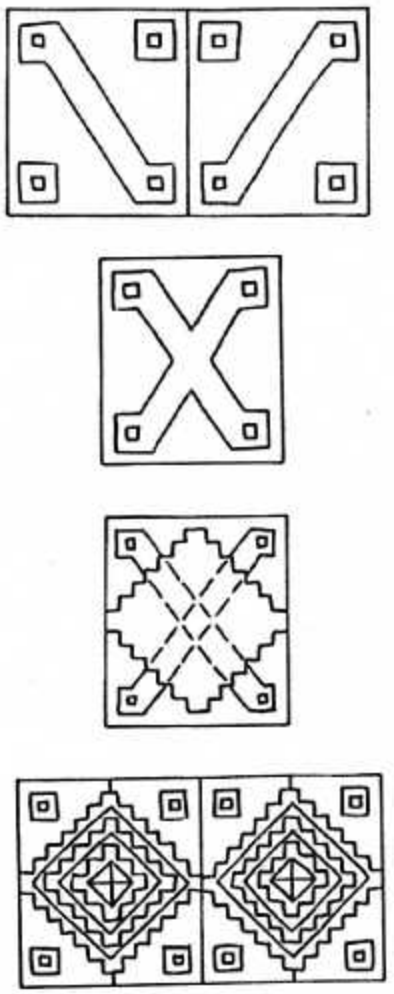

Fig. 11: The conflation of the Inka key graphs and the concentric diamond graph results in the diamond tukapu with squares in the corners (bottom row).

Casana: It is possible to hypothesize how another *tukapu*, one that is called *casana* (figure 12, bottom row), is interrelated with the two just discussed. It is Guaman Poma de Ayala who provides the name of the «*caxana*» in his written description of the tunic illustrated for the fourth Inka, Mayta Capac (1993 [1615]: 98). Guaman Poma is referring to a framed design of four concentric squares in the lower half of the tunic, a design that is on tunics worn by people of different ranks in other illustrations: royalty, nobles, and non-noble warriors [15]. The *casana* design is also abbreviated in illustrations of some tunics to two concentric squares (130), or to one concentric square in bands of *tukapu* (100, 108) and on the chest of a warrior's tunic (151). The *casana tukapu* in Guaman Poma's drawings cross-cuts rank divisions, and is most consistently shown on the garments of men who wear war helmets and/or bear arms (98, 100, 108, 149, 151, 157, 194, 252). Variants of the *casana tukapu* with double frames and vertical bands (250, 1093) or double frames and horizontal bands (277, 344, 352)[16] cluster in different contexts, including the ceremonial breaking of the sod by four men of royal and noble status. The illustrations in Guaman Poma show several contexts in which it was apparently appropriate for men of different rank to wear the *casana tukapu*.

15 Zuidema (1991) provides an informative review of the *casana tukapu* in Guaman Poma's drawings. Both he and J. Rowe (1979) illustrate a tapestry tunic with *casana*. I have located versions of *casana* in painted, feathered, and discontinuous warp textiles. Concentric squares are common graphs on incised wooden *keros* where they repeat in a single band or alternate with another graph in a gridded pattern.

16 Another example with a double frame (1993 [1615]: 281) does not show whether there is a horizontal or vertical band because of the profile view of the person wearing the tunic.

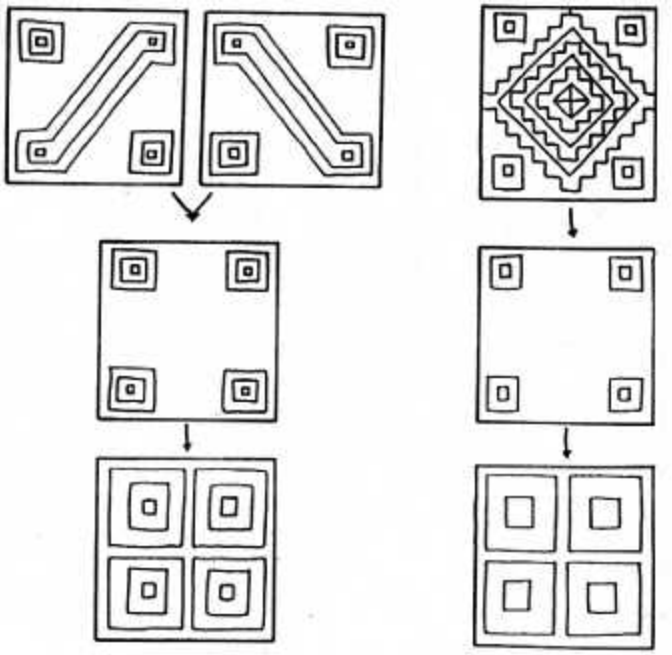

Fig. 12: A small scale version of the casana tukapu is nested within the directional variants of the key graph (left) and the diamond graph with squares in the corners (right). Pie de figura

Examining the occurrence of the *casana* squares as small-scale elements in other *tukapu* on surviving garments offers different clues about the graph, and about operations in the code. Some diamond *tukapu* have four squares near the corners of their frames (figure 7, bottom row; figure 11, bottom) and the Inka key *tukapu* have two squares in the corners (figures 9–11). A conflation of the two directional variants of the Inka key produces two variants: the X-shaped graph already illustrated (figure 11, second row) and a graph consisting of four concentric squares (figure 12, left). Enlarging the squares to fill the frame results in the configuration of the *casana* graph [17]. A similar operation, applied to the diamond *tukapu* with four squares in the corners, also results in the *casana* graph (figure 12, right). The operations illustrated in figure 12 can also be followed from the bottom upward, where they provide a schematic notion of the inverse process of constructing a conflated graph by shrinking and infixing small-scale elements in the frame of another graph. The process of «inventing» *tukapu*, something that the eighth Inka, Viracocha Inka, was industrious about (Sarmiento de Gamboa, 1999 [1572], ch. XXV: 86), might have involved navigating the code via the operations to produce new combinations and configurations. The challenge of invention for the Inka (and his wise men?) may have lain in maintaining the coherence of the relationships embedded in the all of the constituent elements in the invented graph, or perhaps in adjusting the nuances of relations between relations.

A domain of reference that fits with the *casana tukapu* can be proposed from its context as an infixed element in the Inka key and diamond graphs. As both the Inka key and the diamond *tukapu* appear to correspond with socio-political domains, it is probable that the *casana tukapu* will also. The four squares, located in the corners or quadrants of some diamond *tukapu*, suggest that such a socio-political domain will be composed of four independent but not unconnected parts. The four squares in the corners of the diamond *tukapu* conform with the number, the location, and the relative independence of the four *suyus* within the empire. Approaching *tukapu* as diagrammatic frameworks, there is a visual and semantic logic in the location of the *casana* squares in some diamond *tukapu* (and in their omission in others), when they are read in this way. In the Inka key, there are two independent squares in its frame, and two (almost independent) squares that are connected to ends of the diagonal stroke. I have already discussed the congruence between the Inka key and the relationships of the two-part moieties and four-part *suyus* [18].The squares in the corners plus the squared ends of the diagonal tilt at the fourness of the *suyus*, while the diagonal connector in the graph, which occurs in two directional variants and has two-fold rotational symmetry, tilts more strongly at the two-part relationship of the moieties. Again, the squares and squared

17 Zuidema (2003) independently made a similar visual connection between the Inka key graph and the *casana* graph in a conference paper, «*Casana*, Are We Able to Read it as a *Tukapu*?» He noted four concentric squares were adjacent at the corner conjunctions in the checkerboard repetition of Inka keys.

18 The *tukapu* of the Inka key itself appears to be a conflation with infixed and blended elements.

ends are disposed in the four corners of the *tukapu* frame, consistent with the number and general location of the *suyus*. The *casana tukapu* exhibits a significant correspondence with the four *suyus* when it is infixed in other *tukapu*.

The relationships embedded in the formal properties of the *casana tukapu* also correspond with the relationships that underpin *suyu* organization. *Casana* is a grapheme with two axes of reflection located between the four squares. The union of four, rather than the partition of one into four (as proposed for the diamond), is suggested by the four separate squares within a frame. The horizontal axis aligns two upper squares in contrast with two lower squares, a positioning that is analogous to the *hanan/hurin* division between *suyus*. The vertical axis separates right squares from left squares, analogous with the ranked *suyus* within the moiety halves. Like a map without labels, the *casana tukapu* is a fair diagram of the *suyus*: their number, their relative location, their rank divisions, and their union within the Inka empire.

Casana also has four-fold rotation symmetry, that is, it becomes congruent with itself at four points in a dial-like rotation. Four-fold rotation has a potential to convey a temporal cycle with four intervals and a hierarchical order of four. A four-part temporal cycle could have organized a rotational order of obligations among the *suyus* (military or other service), a rotation of crops, or any other periodically recurring activity spread among four groups. The Inkas were particularly well-known for just such orderly fair practices (Cieza de León 1959 [1553, 1880]; Betanzos 1996 [1557]), many of which are based in the strategy of rotation. The sequence of four-fold rotation in a clockwise or counter-clockwise direction could potentially express a circular order of hierarchy. Because of the double dual relationships of rank in the moieties and *suyus*, the four *suyus* have two different rank orders, as mentioned previously. A circular rank order, which places the both of the *hanan suyus* before the *hurin suyus*, is commensurate with the circular rotation of the *casana tukapu* in the clockwise direction when it is viewed as a map: *Chinchaysuyu* (*hanan*), *Andesuyu*, (*hanan*) *Collasuyu* (*hurin*), and *Condesuyu* (*hurin*). Like the Taquile hexagon, the *casana tukapu* has the formal properties of a rudimentary map and calendar, and therefore has the potential to organize human activities in space and time. The properties of symmetry and number, as well as the quadripartite format, in the *casana* graph agree with aspects of *suyu* organization among the Inkas as they are known through the chronicles, and as they continue to be used in some Andean communities today.

In each of the three *tukapus* discussed (the diamond, the Inka key and the *casana tukapu*), the concentric squares have a different weight (figure 12). In the diamond *tukapu*, they are small, presumably subordinate, elements that are sometimes present and sometimes omitted. In the compound graph of the key *tukapu*, the squares in the corners of the frame and on the ends of the diagonal have a weight almost equal to the diagonal itself. In the grapheme of the *casana tukapu*, the squares alone have expressive value. It appears possible that graphic entities, by their size and weight within conflated *tukapu*, could also express nuances of relations between relations, such as subordination, equality, or primacy.

While the discussion of specific *tukapu* has centered on their congruence with socio-political domains of reference, I am not arguing that all *tukapu* refer to this domain, nor do I feel certain that these *tukapu* refer only to this domain. Because *tukapu* appear to express relationships, it must be kept in mind that they could be polysemous. The relationships that they embody may correspond with relationships that underpin other cultural domains as well, ones for which there is less data for tracing correspondences. The Inka penchant for structural ordering may run very deep, and there may be considerable redundancy between the ordering strategies of different domains. If this is the case, then the graphic representation

of these relationships in *tukapu* may be similar. What does seem apparent is that the *tukapu* discussed here do correspond with different spheres of Inka socio-political organization. Both the relationships embedded in the formal properties and the interrelations evident in the conflations of the graphs are consistent with the correspondences I have noted with the socio-political domain.

Conclusions

The particular *tukapu* discussed illustrate the types of relationships that can be embedded in the graphic properties of *tukapu*. The methods I have used can be applied to a wider group of graphs. Tracking the infixed elements, such as concentric squares, leads to other *tukapu* that may have a semantic overlap with those just discussed. Recognizing the abbreviated parts of the diamond, key, and *casana tukapu* in differently configured *tukapu* also extends the network of connections among *tukapu* that may interrelate. Another method employs the analysis of the properties in the code. Graphs with different shapes, but that have the same combination of symmetries, have the potential to express similar types of relationships. For instance, graphs that have both reflection and rotation symmetry (and can thereby embed relationships of space, time, and hierarchical sequence) are useful and economic diagrams for coordinating human activities, as illustrated in the Taquile hexagon.

The illustrated chronicle of the native writer and artist Guaman Poma is particularly enlightening for the group of graphs that have reflection and rotation symmetry. The majority of graphs sketched by Guaman Poma (aside from those he renders as Hindu-Arabic numerals) have the symmetry attributes of the diamond, key, and/or *casana tukapu*. The general sample of *tukapu* on extant objects does not exhibit such a high proportion of these symmetries or combinations of symmetries, a point that may relate to the contexts he depicts. Guaman Poma shows garments with *tukapu* being worn in contexts by people of identifiable socio-political affiliation: Inkas, queens, *hanan/hurin* nobles, captains, dignitaries of the four *suyus*, and soldiers. His illustrations are carefully composed to convey the orderly structure and hierarchy of Inka society. People are positioned in pictorial space to reflect their status, an important insight into his graphic technique that has been recognized and developed by other scholars (Ossio 1970; 1973; Wachtel 1973; Adorno 1979). He uses ranked pairs (center over periphery, right over left, front over back, up over down) to convey the relative status of people in his illustrations. Those who are in the center, particularly the front and center, have the highest rank. Those on the proper right (viewer's left) rank above those on the proper left of an illustration. Those in the foreground rank above those in the background. Armed with this insight, it is possible to recognize the rank of persons in complex drawings such as the Inka and His Royal Council (figure 13). As a native artist, Guaman Poma has imported an indigenous formatting technique into his Europeanized drawings to

Fig. 13 The tukapu on the Inka's tunic correspond with different spheres of socio political organization that are embodied in the people in the illustration of the Inka and his Royal Council. Guaman Poma 1993 (1615): 364.

graphically convey rank through the location of people in pictorial space.

As discussed previously, pairs are a primal format for expressing relationships of rank in Inka *tukapu*. I will illustrate that Guaman Poma also uses the paired format to express rank when he locates *tukapu* on the Inka's tunic (figure 13). In the course of doing so, I will illustrate that the *tukapu* are referenced to people or groups of people belonging to identified socio-political domains (see also Frame 2003). Taken together, these new associations suggest that Guaman Poma is using both the formatting technique, and the *tukapu* code itself, to convey meaning graphically.

The set of six *tukapu* on the Inka's tunic (figure 13) repeat in diagonal rows in the upper section and less completely in the lower section, where the graphs run in reversed order [19]. The tunic worn by the Inka has the diamond and Z-shaped key graphs in the central diagonals of the main repeat, underlining the correspondence of these graphs with the central people in the drawing. The Inka is ringed by the moiety nobles in the foreground and the representatives of the *suyus* in the middle ground, while the general populace is in the background. According to my analysis of the concentric diamond, it corresponds with all the people who ring the Inka – the entire empire centered on the Inka. Again according to my analysis, the Inka key *tukapu* on the tunic corresponds with the sub-group of moiety nobles and the representatives of the *suyus* in the foreground and middle ground respectively. The imperial relationships of the diamond graph and the moiety/*suyu* relationships of the key graph (here drawn as a Z shape) are given pride of place on the tunic in the center of the main repeat.

The Inka's tunic exhibits a further set of four *tukapu*, which appear to correspond individually to the representatives of the four *suyus*. There is convincing evidence for associating three of the four with particular *suyus* [20]. The eight-rayed figure can be associated with *Chinchaysuyu* because it surmounts the feather plume or repeats on garments of *Chinchaysuyu* men in most illustrations of them. The eight-pointed star can be associated with Condesuyu through its repetitive use on textiles and ceramics known as Chuquibamba (Frame 1999), one of the major polities in *Condesuyu* before and during the Inka period. The stepped triangle *tukapu* can be associated with *Collasuyu* because Guaman Poma shows a band variant of it on the tunic waistbands of two *Collaysuyu* men (1993 [1615]: 293, 324). By elimination, the cross *tukapu* with circle terminals should be associated with *Andesuyu*.

Also of importance here is the location of the *tukapu* (now identified with *suyus*) within the main repeat on the tunic (figure 13). The *tukapu* on the two diagonals above the diamond and key diagonals correspond with the two *suyus* in the upper moiety, *Chinchaysuyu* and *Andesuyu* (and to the captains of the *suyus* on the Inka's right). The *tukapu* on the two diagonals below the diamond and key correspond to the *suyus* of the lower moiety, *Collasuyu* and *Condesuyu* (and to the captains of the *suyus* on the Inka's left). Guaman Poma uses the indigenous format of ranked pairs (above/below) to reiterate the moiety status of the *tukapu* and their associated *suyus* – just as he reiterates the status of the four captains of the *suyus* through their location in pictorial space.

Furthermore, the *tukapu* that correspond to each of the four *suyus* all have reflection and rotation symmetry, but have varying numbers of partitions and intervals as well as distinct shapes. The presence of two symmetries indicates that all four *tukapu* have a potential to embed similar types of relationships (the conjunction of space and time, and hierarchy, for

19 One *tukapu* (stepped triangles) belongs to both repeats. Sharing one *tukapu* with both repeats allows the inversion of the order in the second repeat without having the same *tukapu* in adjacent diagonals.

20 The evidence for associating each of the four graphs with a particular *suyu* is detailed more fully elsewhere (Frame 2003).

instancel in their configuration. The four *tukapu* appear to function both as discrete «emblems» of the *suyus*, as well as diagrammatic frameworks that could organize people and activities internally according to particular programs.

Steeped in the native graphic tradition as he was, Guaman Poma drew on the formats of his own graphic mode of discourse to express Inka organization in his Europeanized illustrations. What has not been recognized before now is that he also was using the indigenous discourse mode of *tukapu* in his illustrations. Guaman Poma invented a hybrid illustration style that conflates two graphic traditions. As a result, what we appear to have in figure 13 is an authentic document «written» in *tukapu* and simultaneously «translated» for European eyes.

Ethnohistoric sources, particularly those written and illustrated by native chroniclers, will continue to be a valuable source for *tukapu* studies. They are also useful sources for cross checking the hypotheses generated from formal analyses of the *tukapu* code. In Guaman Poma, we have an independent source for four more *tukapu* that seem to clearly have socio-political domains of reference, and all four have the dual symmetries of rotation and reflection. One implication is that the presence of dual symmetries (reflection and rotation) in *tukapu* might signal a socio-political domain of reference, or at least a domain in which the conjunction of space and time is a basic relationship. Guaman Poma's use of indigenous formatting principles in the location of *tukapu* on the Inka's tunic (figure 13) supports the domains of reference proposed earlier for the diamond and the key *tukapu*, as he places the diamond and key in the center of the main repeat. The overall approach to *tukapu* developed here is also bolstered by Guaman Poma's diagrammatic approach to pictorial space, his use of native formatting principles, and his use of the *tukapu* code itself.

The code of *tukapu* differs markedly from ancient writing systems that have been described. The system does not appear to be alphabetic, syllabic, pictographic, or logographic, although it may have elements of the latter two [21]. I propose that geometric *tukapu* are predominantly diagrams, rather than logograms. As diagrams, *tukapu* exhibit frameworks of relationships that are not commensurate with phonetic utterances. In fact, it is difficult to put the network of relationships embedded in the configuration of *tukapu* into words. The domains of reference of some *tukapu* were perhaps summarily named [22], but such tag-like names would not express the complexity of relationships that is at the heart of «the logic that drives and orders» (Boone 1994) the *tukapu* code. Names would be inadequate glosses for the webs of relationships that are encompassed in the diagrams.

This newly described type of code operates on a more abstract level and expresses relations with greater nuance than is generally attributed to semasiographic, or non-glottalized, systems. The configurations of *tukapu* appear to reiterate relational postulates that are insistently present in Inka discourse. The linguist Sampson recognizes the abstract possibility that semasiographic systems could be expanded until they were «fully as complex and rich in expressive potential» as spoken language. However, he flatly states that «in practice no semasiographic system is anywhere near this comprehensive» (1985:30). The code of *tukapu*,

21 Logograms are signs that stand for words or sounds. The rarer figurative graphs of birds, snakes, tunics and insects may be partially logographic or pictographic. Because they have variants that are generated by standard operations such as repetition and reversal, it appears that the configuration of properties also influences the overall expression.

22 The diamond *tukapu* could conceivably have been named «*Tawantinsuyu*», in accordance with the graphic partition into four and the imperial domain of reference that I have suggested here. However, this hypothetical naming of the graph in accordance with the property of reflection symmetry does not encompass the full range of relationships expressed in the other properties, which suggests such a name would not be entirely glottographic.

one of the viable and complex literacies that the Inkas were using at the time of the conquest, appears to be a type of semasiographic system that was fully as complex and rich in expressive potential as relational thinking.

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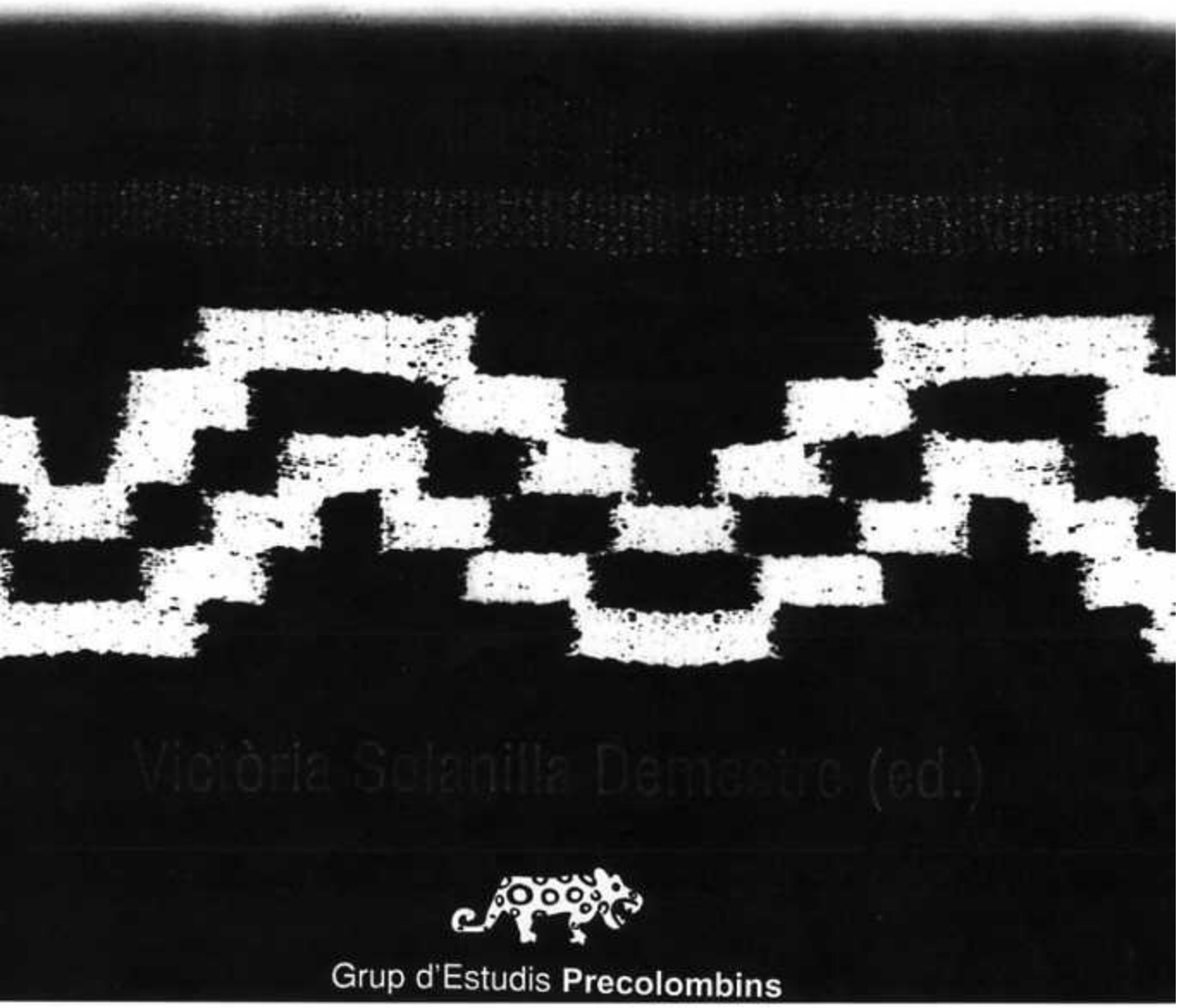

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